

**A TOTAL MAXIMUM DAILY LOAD ANALYSIS
FOR BATTERSON PARK POND,
FARMINGTON/NEW BRITAIN, CONNECTICUT**

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**This document has been established
pursuant to the requirements of Section
303(d) of the Federal Clean Water Act**

JANE STAHL **11/29/04**

Jane Stahl, Acting Commissioner Date
Air, Waste and Water Programs

YVONNE BOLTON **11/29/04**

Yvonne Bolton, Acting Chief Date
Bureau of Water Management



**STATE OF CONNECTICUT
DEPARTMENT OF ENVIRONMENTAL
PROTECTION
79 Elm Street
Hartford, CT 06106-5127
(860) 424-3020**

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INTRODUCTION

The Federal Clean Water Act (CWA) provides regulations for the protection of streams, lakes, and estuaries within the United States. Section 303(d) of the CWA requires individual states to identify waters not meeting current state water quality standards due to pollutant discharges and to develop Total Maximum Daily Loads (TMDLs) for these waters. A TMDL sets the maximum amount of a substance that a waterbody can receive without exceeding current state water quality standards. Waterbodies for which Connecticut is required to develop TMDLs are included on the *2004 List of Connecticut Waterbodies Not Meeting Water Quality Standards*⁽¹⁾ (*2004 List*). Such waterbodies are identified on the *2004 List* as Tiers 2 and 3. Batterson Park Pond is included on the *2004 List* as a Tier 2 waterbody due to impairment of recreational use caused by excessive nutrient conditions. As such, TMDLs for nutrients (nitrogen and phosphorus) have been prepared for Batterson Park Pond and are presented herein.

The purpose of the Batterson Park Pond TMDL is to establish nitrogen and phosphorus loading targets that, if achieved, will result in consistency with the *State of Connecticut Water Quality Standards*⁽²⁾ (WQS). Water quality that is consistent with state standards is expected to protect designated uses, and implies that conditions will be similar to those expected under natural conditions without undue human influence. This TMDL analysis was prepared following the Environmental Protection Agency's (EPA) protocol for developing nutrient TMDLs⁽³⁾. The main objectives of this TMDL report include the following:

- describe existing conditions and applicable standards and guidelines;
- estimate the loading capacity of Batterson Park Pond;
- assign loading capacities for existing and future sources ;
- establish a margin of safety;
- account for seasonal variation;
- develop a monitoring plan;
- develop an implementation plan;
- provide reasonable assurances that the plans will be acted upon; and
- describe public participation in the TMDL process.

Determining the maximum daily nutrient load that a waterbody can assimilate without exceeding water quality standards is challenging and complex. First, many lakes receive a high portion of their nutrient loading from non-point sources, which are highly variable and are difficult to quantify without a substantial data set. Secondly, lakes demonstrate nutrient loading on a seasonal scale, not a daily basis. Loading during the winter months may have little effect on summer algal densities. Additionally, the nutrient loading capacity of lakes is typically determined through water quality modeling, which is usually expressed on an annual basis. Therefore, it is most appropriate to quantify a lake TMDL as an annual load and evaluate the

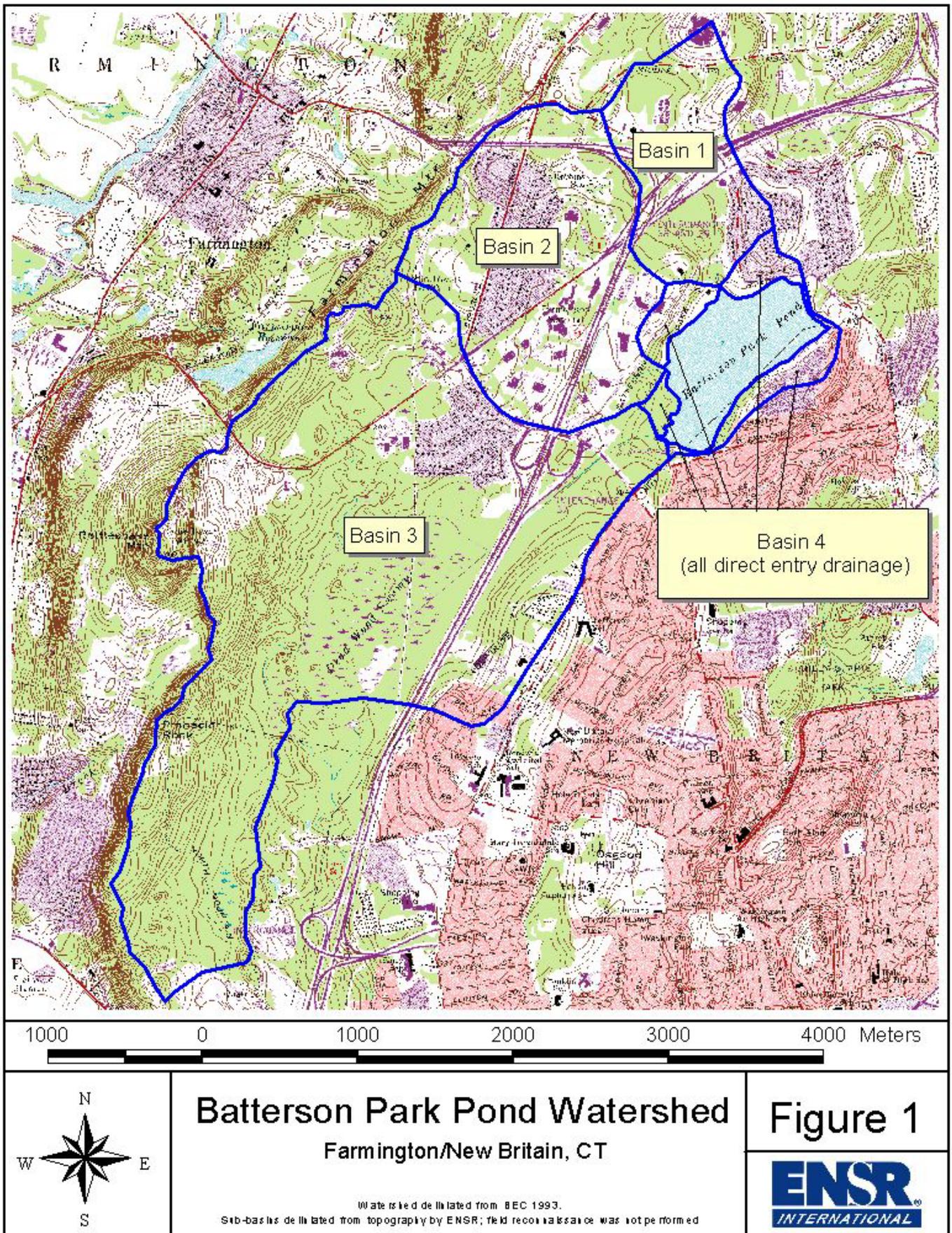
results of that annual load on mid-summer conditions that are most critical to supporting recreational uses. Finally, variability in loading may be very high in response to weather patterns, and the forms in which nutrients enter lakes may cause increased variability in response. Consequently, while a single value may be chosen as the TMDL for each nutrient, it represents a range of loads with a probability distribution for associated water quality problems (such as algal blooms). Uncertainty is likely to be very high, and the TMDL should be viewed as a nutrient-loading goal that helps set the direction and magnitude of management, not as a rigid standard that must be achieved to protect against eutrophication.

DESCRIPTION OF THE WATERBODY

Much of the waterbody information presented in this section was obtained from a Diagnostic Water Quality Study ⁽⁴⁾ (DWQS) of Batterson Park Pond completed by Baystate Environmental Consultants, Inc. (BEC) for the City of Hartford in April 1993.

Batterson Park Pond is a 165-acre freshwater lake owned by the City of Hartford and located in Farmington and New Britain, Connecticut (Hartford County). The lake and its 2,709-acre watershed lie within the Connecticut River basin and form the headwaters of Bass Brook. The watershed is divided into four sub-basins and is outlined in Figure 1. The maximum and mean water depths are 21.7 and 17.0 feet, respectively. The lake volume is approximately 122 million cubic feet, with a retention time of approximately 200 days (flushing almost twice per year). The watershed is mostly comprised of forested (64%) and developed urban (25%) areas. The remaining eleven percent of the watershed consists of agriculture and open land. Base flow from the watershed accounts for 12% of the total inflow to Batterson Park Pond. Storm flow provides 49% of the annual water input. The remainder of the water load is attributed to direct precipitation and ground water seepage. As a result of high stormwater and direct precipitation inputs, the detention time of Batterson Park Pond varies strongly in response to precipitation.

Limited stormwater controls exist throughout the watershed, lowering nutrient and solids loading to the lake only slightly. The lake experiences non-algal turbidity in response to inclement weather (runoff with soil erosion), algal blooms under low-flow conditions (high fertility with low flushing), and excessive rooted plant density. Excessive nitrogen and phosphorus are the root cause of eutrophication in Batterson Park Pond and are therefore the subject of this TMDL. However, it should be noted that while past watershed inputs are to some extent responsible for current rooted plant growths, reduced nutrient loading is not expected to control those growths now that a nutrient-rich sediment base has accumulated. In-lake management actions will be required to address impairment caused by rooted plants and are not included in this TMDL.



PRIORITY RANKING AND POLLUTANTS OF CONCERN

Batterson Park Pond is included on the 2004 *List* due to impairment of recreational use caused by excessive anthropogenic nutrient (nitrogen and phosphorus) loading. Batterson Park Pond is ranked a "T" priority on the 2004 *List*, which indicates that the waterbody is currently under study and may lead to development of a TMDL within the next two years if warranted. The Connecticut Department of Environmental Protection (DEP) has determined that establishing a TMDL based on the results of the DWQS, is an appropriate pollution control strategy.

POLLUTANT SOURCES

Identification of Sources:

Nitrogen and phosphorus sources identified in the DWQS include the following:

- atmospheric deposition (direct precipitation to the lake)
- ground water in seepage (direct seepage into the lake)
- surface water base flow (dry weather tributary flows, including any seepage into streams)
- surface water storm flow (runoff added to tributaries or directly to the lake)
- waterfowl (direct inputs to the lake from birds)
- internal recycling (release from the sediment, either by chemical interaction with overlying waters, resuspension by wind, macrophyte decay, and "pumping" by macrophytes)

There are no permitted point source discharges of nutrients in this watershed, with the exception of some stormwater discharges that are regulated as point sources under the federal NPDES regulations.

Analysis of Current Loading:

Current nitrogen and phosphorus loading values were assessed using the following four methods:

1. The budget directly from the DWQS. This budget was outlined in the DWQS for Batterson Park Pond and was determined by BEC through a combination of direct measurements, export coefficients, and empirical data. Some assumptions were necessary. As a result, this budget may differ from other available methods or combinations thereof with different assumptions.
2. Raw data (water budget and nutrient concentrations) provided in the DWQS study. These data were used to calculate the base and storm water loading. Internal loading was calculated based on in-lake data provided in the DWQS. The raw data combined

with loading provided in the DWQS for precipitation, waterfowl and groundwater seepage were used to estimate an annual nutrient budget. This type of direct assessment approach is a traditional method of evaluating loading, but requires substantial data to be reliable. As all individual sources are not directly assessed in field studies, extrapolation and estimation may still be necessary. However, direct measurement provides real data upon which to base loading estimates, and acts as a valuable reality check on modeling approaches.

3. The average of empirical models (Bachman ⁽⁵⁾, Kirchner-Dillion ⁽⁶⁾, Vollenweider ⁽⁷⁾, Reckhow ⁽⁸⁾, Larsen-Mercier 1976 ⁽⁹⁾, and Jones-Bachmann ⁽¹⁰⁾). Empirical models generate estimates of the load necessary to achieve observed in-lake conditions, based on system features such as depth and detention time. They are based on relationships derived from many other lakes. As such, they may not apply accurately to any one lake, but provide an approximation of current loading and a reasonable estimate of the direction and magnitude of changes that might be expected if loading is altered.
4. Calibrated land use export coefficient model developed by ENSR ⁽¹¹⁾ under contract to the DEP. Export coefficient models depend on empirical or assumed yields of water and nutrients from the watershed as a function of land use. Yields are assigned to each defined parcel in each defined sub-basin of the pond (Figure 1). These yields can be modified as they move toward the lake through attenuation factors, based on distance to the lake, soils and any Best Management Practices (BMPs) in place. The export coefficient model employed here was developed by Ken Wagner, Ph.D. of ENSR for use in southern New England, and allows the user to select yield coefficients and attenuation factors from a range appropriate to this area. Values encompass those applied in the Long Island Sound Study ⁽¹²⁾ and work by Frink and Norvell ⁽¹³⁾ at the Connecticut Agricultural Station over many years. The generated load to the lake is processed through the empirical models noted above to derive estimates of in-lake concentrations and effects on algal productivity and water clarity. This model is most effective when calibrated with water quality data for the target system. While it is a spreadsheet model with inherent limitations on applied algorithms and resultant reliability of predictions, it provides a rational means to link actual water quality data and empirical models in an approach that addresses the whole watershed and lake.

This combination of four methods yielded a range of probable loads and provided a reasonable approximation of actual conditions over the longer term. Actual sample results were used in direct calculations. Literature values were used when actual measurements were not gathered (i.e., waterfowl, internal loading, ground water and precipitation). From the four methods, total nitrogen loading ranged from 7,109 to 8,578 kg/yr and total phosphorus loading range from 402 to 794 kg/yr. Results of each method are provided in Table 1.

Table 1. Annual Nitrogen (N) and Phosphorus (P) Loading to Batterson Park Pond.

Method	Method ID Number	Nitrogen (kg/yr)	Phosphorus (kg/yr)
Existing DWQS	1	8578	794
Existing Raw Data	2	7109	443
Empirical Model Average	3	7612	483
Land Use Export Coefficient	4	8473	402
Mean of all Methods		7943	530

The phosphorus loading estimates are similar for three of four approaches, with a higher estimate derived from the DWQS. This higher annual estimate is a function of a higher estimate of the internal phosphorus sediment loading. Sediment loads initially calculated by BEC from collected data were thought to be too low (110 kg/yr) therefore BEC used a literature value (300 kg/yr) in lieu of direct calculation. In comparison, the internal loading value calculated from the export coefficient model (method 4) was 48 kg/yr.

Based on methods 1, 2, and 4, direct precipitation provides approximately 3-4% of the annual nitrogen load and 3-7% of the annual phosphorus load. Groundwater in-seepage provides 23-28% of the annual nitrogen load and approximately 9-16% of the phosphorus load. Total surface flow provided 46-86% of the nitrogen load and 24-44% of phosphorus inputs. Waterfowl provide 8-10% of the nitrogen loading and 19-37% of the phosphorus load. Internal recycling is estimated to provide 3-13% of nitrogen loading and 12-44% of phosphorus loading. While these ranges may seem wide for some input sources, they are believed to represent a realistic range of inter-annual variability likely in this case.

Background conditions were estimated by modifying the land use export coefficient model. Once the model was calibrated to reflect current conditions in the watershed of Batterson Park Pond, land use was changed to reflect pre-development background conditions (i.e. forested and wetland conditions), the internal phosphorus load was reduced by 50% (an estimate of more natural internal loading level), and waterfowl loading was reduced by 40%. Background nitrogen and phosphorus loads under this scenario were 3,312 and 195 kg/yr, respectively (2,707 and 67 kg/yr from the watershed alone). Using the loading rates, background in-lake nitrogen and phosphorus concentrations were predicted from empirical models to be 446 and 24 ug/L, respectively. As such, the necessary reductions for total nitrogen and total phosphorus, in order to return the watershed to expected “background” loading conditions, were determined to be 53-61% (total nitrogen) and 51-75% (total phosphorus).

Assumptions and Calculations Regarding Nitrogen and Phosphorus Sources:

Estimation of nutrient loading involves assumptions and can be derived in multiple ways. To facilitate understanding of the approaches applied here, the following listing of assumptions and calculation methods is offered:

Hydrologic Inputs

Direct precipitation

- Direct precipitation to Batterson Park Pond was calculated in the DWQS by multiplying total precipitation by lake area. Precipitation data was taken from August 1991 to August 1992 at the Shuttle Meadow Reservoir Station and Brainard Field (located in Hartford).

Surface Water Base & Storm Flow

- In the DWQS, measured flow values were used to calculate the annual hydrologic budget. These values were compared to typical watershed yield rates, runoff and base flow coefficients, and similar watersheds in addition to a mean flow calculation and an average annual inflow rate was estimated. Proportioning flow to base and storm flow was accomplished using historic values from the region and tempering them according to land use and soil groups occurring within the watershed.
- Flows by sub-basin were calculated using the raw data provided in the DWQS (method 2). An annual flow estimate was calculated and the percent contribution of each sub-basin was determined. The percent contributions of sub-basins were used to proportion out the annual flow provided in the DWQS (the literature tempered value) to obtain flow estimates by sub-basin. For example, using existing raw data, sub-basin 1 storm flow was 26% of all storm flow. Therefore, 26% of the total inflow reported in the DWQS study was used for sub-basin 1.
- For the Land Use model, the total flow reported in the DWQS was used. Runoff coefficients were adjusted to match the total inflow provided in the DWQS.
- The DWQS value was used in the empirical models.

Ground Water

- Ground water contribution was estimated by subtracting the precipitation, base and storm flow contribution from the total estimate inflow to Batterson Park Pond.

- Existing raw data for groundwater and land use export ground water values were calculated using the same method (#2) as was used for the surface water base and storm flows.

Nutrient Inputs

DSWQ

- A combination of empirical data and measured data were used to estimate nutrient loading to Batterson Park Pond.

Existing Raw Data (raw data from DWQS)

- Nutrient concentrations for base and storm flow were multiplied by corresponding hydrologic inputs to obtain an estimated load.
- High variability in stormwater phosphorus concentrations resulted in a high range of phosphorus loading.
- Nutrient concentrations were halved to account for overestimation by first flush sampling.

Empirical Models

- Hydrologic lake features and known in-lake concentrations were used to back-calculate the nutrient load required to obtain observed in-lake concentrations.
- A single three-part model was used for nitrogen (Bachman ⁽⁵⁾) and an average of five phosphorus models was applied (Kirchner-Dillion ⁽⁶⁾, Vollenweider ⁽⁷⁾, Reckhow ⁽⁸⁾, Larsen-Mercier ⁽⁹⁾, and Jones-Bachmann ⁽¹⁰⁾).

Land Use Export Coefficient Model

- Nutrient export coefficients from the literature for different land use types were used to calculate potential nutrient loads.
- Loads were reduced based on estimated natural attenuation and any existing water quality control devices, and adjusted based on comparison of results with existing data.
- Once calibrated for the specific watershed, this model is also used to predict impacts of watershed management actions.

Relationships

- It was assumed that water transparency and chlorophyll *a* concentrations in Batterson Park Pond are mathematically related to total phosphorus concentrations as described by Carlson⁽¹⁴⁾ and Frink and Norvell⁽¹³⁾. Interference by non-algal turbidity, toxicity, or other possible factors is assumed to be minimal.

Summary:

Batterson Park Pond is a bowl shaped, 165-acre freshwater lake with a 2,709-acre watershed. While the dominant land use is forest, substantial urban land-uses affect incoming water quality. In-lake water quality is dependent on the quality of surface water entering the lake from the watershed and internal recycling (including waterfowl). Inadequate stormwater controls and active internal processes have led to a decline in water quality and high variability of in-lake water quality. Excessive nitrogen and phosphorus loading over time has led to increased frequency and duration of algal blooms. Accumulated nutrient-rich sediment deposits support excessive rooted plant densities.

Multiple nutrient loading approaches provide estimates of the loads of nitrogen and phosphorus to Batterson Park Pond that can be compared to desirable loading levels, based on water quality standards relating to use attainment goals. The current loading of nitrogen is estimated to range from 7,109 to 8,578 kg/yr, while the estimated loading range for phosphorus is 402 to 794 kg/yr. Background nitrogen and phosphorus loading was estimated to be 3,312 kg/yr and 195 kg/yr, respectively. As such, a 53-61% reduction in current total nitrogen loading and 51-75% reduction in current total phosphorus load would be necessary to return the watershed to expected “background” loading conditions. Stormwater and internal loading (including waterfowl) are considered to be the dominant and most controllable sources.

APPLICABLE WATER QUALITY STANDARDS

Batterson Park Pond has been assigned a surface water classification goal of A by the State of Connecticut. Surface water classifications are not a measure of water quality but rather they establish designated uses for a waterbody. Designated uses for Class A waters include recreation, fish and wildlife habitat, potential drinking water supply, industrial and agricultural water supply, and navigation. Existing uses for Batterson Park Pond include habitat for fish, other aquatic life, and wildlife, and recreation.

The applicable water quality standards for Batterson Park Pond include Surface Water Criteria, and Lake Trophic Categories. The surface water standards criteria for nitrogen and phosphorus,

which Batterson Park Pond TMDLs have been derived for, are narrative. Surface water quality standard numbers 8, 13, 19, and 20 of the WQS ⁽²⁾ aid in the interpretation of such criteria. Specifically, standard 8 specifies that only those nutrients that remain following application of Best Management Practices (BMPs) can be considered to be of natural origin. Achieving consistency with this standard requires that 1) BMPs be used to minimize nutrient releases resulting from human activity and, 2) the nutrient loading that remains following implementation of BMPs does not result in adverse impact to existing or designated uses. As noted in the previous section, current practices to manage stormwater runoff are inadequate and much of the present nutrient loading to the lake cannot be considered natural due to the absence of effective BMPs. In order for the nutrient loading to be considered natural and consistent with standard 8, additional BMPs must be implemented in the watershed. Further, the post-BMP implementation loading must not adversely impact an existing or designated use in order to be considered natural. This determination is made based on an examination of the impact of the projected post-BMP loading on recreational uses. Recreational uses in lakes are primarily determined by the lake's trophic category. Nutrient loading that results in a change to a lakes natural trophic category represents an adverse impact to designated recreational uses.

The lake trophic categories include numerical expected ranges for total phosphorus, total nitrogen, chlorophyll *a*, and secchi disk transparency. The values of total phosphorus, total nitrogen, chlorophyll *a*, and secchi disk transparency parameters vary depending on the lake trophic category. Designated recreational uses will be fully supported and maintained for lakes that do not exceed the numerical values for their natural trophic category. The natural trophic categories are determined through assessments of the lakes, absent of significant cultural impacts. Based on the surface area and depth, watershed size relative to lake area and volume, and natural features of the watershed, the natural trophic state of Batterson Park Pond is expected to be mesotrophic to late mesotrophic. In-lake concentrations based on background loading was estimated to be 446 ug/L and 24 ug/L for nitrogen and phosphorus, respectively. Connecticut WQS include the following concentration ranges for nutrients, chlorophyll *a*, and transparency as a guideline for evaluating attainment of mesotrophic conditions:

Total Phosphorus	10 - 30 ug/L spring and summer
Total Nitrogen	200 - 600 ug/L spring and summer
Chlorophyll <i>a</i>	2 - 15 ug/L mid-summer
Secchi Disk Transparency	2 - 6 meters mid-summer

However, Batterson Park Pond currently has elevated nutrient concentrations, high productivity, excessive plant densities, and limitations on some forms of recreation that are an apparent consequence of human-derived inputs that have not been effectively managed by implementing BMPs. The current trophic category for Batterson Park Pond is eutrophic while the trophic

condition that would exist under in the absence of significant cultural impact is mesotrophic to late mesotrophic. To achieve consistency with Connecticut WQS and fully support designated recreational uses, nutrient loading to Batterson Park Pond must be reduced.

Mesotrophic lakes generally provide good opportunities for water contact recreation. A significant percentage of the mesotrophic lakes in Connecticut have designated swimming areas and other "primary" contact activities such as water skiing and tubing. Boating and other "secondary" contact uses are considered recreational uses in mesotrophic lakes as well. There may be brief times during the year or limited areas of a mesotrophic lake where aesthetic considerations (i.e. macrophyte growth or short duration algal blooms) cause some reduction in the level of recreational activity. These limitations are not considered to be "impairments" since they reflect the normal and expected conditions in a mesotrophic lake.

TOTAL MAXIMUM DAILY LOAD

Batterson Park Pond is included on the 2004 *List*⁽¹⁾ for impairment to recreational uses caused by excessive nutrient concentrations. Although phosphorus and nitrogen are naturally occurring elements, the amount of these nutrients entering Batterson Park Pond has increased due to anthropogenic activities (development, fertilizer use, direct stormwater piping to the lake, and inadequate stormwater controls) and increased use by waterfowl. Increased nutrient loading has led to increased phytoplankton densities, reduced water clarity, poor aesthetic quality, and low dissolved oxygen near the lake bottom, as well as altering natural color, taste and odor. Excessive rooted plant density decreases aesthetic value and impairs designated uses such as recreation, navigation and potentially fish and wildlife habitat. Excessive rooted plant densities are more a function of accumulated nutrient-rich sediment and non-native invasive plant species than water column nutrient concentrations. Nutrient-rich sediments are ultimately derived from watershed loading.

In order to achieve conditions consistent with Connecticut WQS, the TMDL must be based on reducing current loads to a level that can be considered "natural". This equates to the loading that will be achieved following implementation of Best Management Practices (BMPs) to control nutrients throughout the watershed, provided that the target loading does not adversely impact on any existing or designated uses.

The TMDL for Batterson Park Pond is expressed as an annual load with the critical time being spring and early summer (See the "Seasonal Variation" section for a discussion of the critical time and seasonal loading component of the TMDL.). As required, the TMDL accounts for waste load allocations (WLA) for all point sources, including stormwater discharges regulated under the NPDES program; and load allocations (LA) for all nonpoint sources, as well as

background levels, and a margin of safety (MOS) which accounts for any uncertainty regarding the relationship between waste load and load allocations, and water quality. The equation for the TMDL analysis is as follows:

$$\text{TMDL} = \text{LA} + \text{WLA} + \text{MOS}$$

The following section describes how the target loading was estimated. Based on the target loading, the expected resulting conditions for Batterson Park Pond were modeled and evaluated with respect to achieving compliance with the WQS (Appendix A).

Target Loading:

Target loads for nitrogen and phosphorus to Batterson Park Pond were determined using the land use export coefficient model (method 4). This approach was selected because it provides loading estimates based on land use categories and allows for reductions to be applied toward land use categories associated with urban and industrial uses where it is expected that BMPs will be applied. In addition, this method calculates stormwater flow, which is needed in order to separate allocations for regulated and non-regulated storm water as requested in the EPA's 2002 Guidance Memorandum ⁽¹⁵⁾.

As previously mentioned, a 53-61% in current total nitrogen loading and a 51-75% reduction in current total phosphorus loading would be necessary to return the watershed to expected "background" loading conditions. Realistically, an aggressive reduction of nitrogen and phosphorus loading attained by using BMPs applied to manageable sources is expected to result in loading reductions on the order of 60% ⁽¹⁶⁾. Greater reductions are possible without consideration of costs, space requirements, or legal ramifications (e.g., land acquisitions), but most techniques applied in a practical manner do not yield >60% reductions in nitrogen or phosphorus loads. The form of nitrogen or phosphorus will have a substantial impact on achievable loading reduction and choice of BMPs, with particulate forms easier to reduce than dissolved forms. Dissolved forms of nitrogen, especially nitrate, are particularly hard to remove except with anaerobic wetland treatments. Aerated soil will remove particulate phosphorus by filtration and adsorption, but substantial detention time is needed to remove dissolved forms. The assumption of a 60% reduction in nitrogen and phosphorus from the total watershed load is ambitious but possible for the Batterson Park Pond watershed. In addition, a 50% reduction of nitrogen and phosphorus from waterfowl (for nitrogen and phosphorus) and internal loading (for phosphorus) is expected.

A 60% reduction of total nitrogen watershed load associated with urban and industrial land uses combined with a 50% reduction from waterfowl would result in a total annual nitrogen load of

4,943 kg/yr (Table 2). A 60% reduction of the total phosphorus watershed load associated with urban and industrial land uses combined with a 50% reduction in internal loading and 50% reduction in waterfowl loading of phosphorus within Batterson Park Pond would result in a total annual phosphorus load of 222 kg/yr (Table 2). This reduction is estimated to result in corresponding in-lake concentrations of nitrogen and phosphorus of 498 ug/L and 22 ug/L, respectively. Upon the implementation of BMPs within urban land use areas, nutrient loading could be considered "natural" provided it does not result in adverse impacts to designated uses.

Table 2. Summary of Total Nitrogen and Total Phosphorus Current Load, Post-BMP Implementation Load, and Predicted In-lake Concentrations.

Source	Current Conditions			Post – BMP Implementation			
	Watershed Load (kg/yr)	Other Load (kg/yr)	Total Load (kg/yr)	Watershed Load (kg/yr)	Other Load (kg/yr)	Total Load (kg/yr)	In-lake Concentration (ug/L)
TOTAL NITROGEN							
Export Coefficient Model	7270	1203	8473	4097	846	4943	498
TOTAL PHOSPHORUS							
Export Coefficient Model	175	227	402	95	127	222	22

Determination of the Regulated Stormwater Load

EPA's 2002 Guidance Memorandum ⁽¹⁵⁾ requires that TMDL analyses provide separate allocations for “regulated” and “non-regulated” stormwater. Regulated stormwater is defined by EPA as stormwater that is discharged through a point source (discrete outfall) that requires a permit under federal NPDES regulations. This includes stormwater discharged from industrial facilities and construction sites covered under the “Phase I Rule” ⁽¹⁷⁾, and municipal small separate storm sewer (MS4) discharges covered under the “Phase II Rule” ⁽¹⁸⁾. Regulated stormwater loading was approximated by overlying the sub-basin map for Batterson Park Pond (Figure 1) with the Census Bureau's urban area boundaries map. It is assumed that runoff from urbanized watershed areas is more likely to be captured by stormwater drainage systems that are regulated under the federal NPDES program. The entire watershed of Batterson Park Pond is located within the designated urban areas, and therefore stormwater loading from all four basins was considered regulated (Table 3). Regulated stormwater constitutes the Waste Load Allocation. The target loading for regulated stormwater is presented in Table 5.

Table 3. Distribution of current Regulated and Non-regulated Stormwater Loading.

Stormwater Distribution	Total Nitrogen (kg/yr)	Total Phosphorus (kg/yr)
Current Conditions		
Surface Water Base Load (includes groundwater load)	3344	1
Stormwater Load	3926	174
Total Watershed Load	7270	175
Regulated Stormwater Load	3926	174
Non-regulated Stormwater Load	0	0

Load Allocation

The non-point source load allocation for Batterson Park Pond includes allocations to surface flow, internal loading (release from sediment), atmospheric deposition, groundwater in seepage, and waterfowl loading.

The phosphorus load allocation for internal sediment recycling (i.e., release from sediment) is half the estimated current load, or about 24 kg/yr, and is most likely to be achieved by nutrient inactivation. Reduced loading from the watershed may eventually lead to reduced internal loading, but it is not expected that this will happen shortly after BMP implementation. While the phosphorus load from internal sources is small relative to watershed inputs, the timing of this load in the summer season and the potentially high availability of the associated phosphorus make it a logical target for load reduction. A major but temporary reduction in phosphorus concentration in Batterson Park Pond may be realized as a consequence of inactivation of internal nutrient reserves, so the reduced load allocation for internal loading may have disproportionately larger benefits. No internal load reduction is proposed for nitrogen. The load allocation for waterfowl is about half for both nitrogen and phosphorus and is most likely to be achieved through waterfowl deterrents.

Load allocations for the other itemized sources (atmospheric deposition and groundwater seepage) are set at average current levels. No reduction is assumed, as it is unlikely that any meaningful control of atmospheric or groundwater seepage loads can be exercised. Such control is not necessary, however, to achieve the targeted loading level.

Table 4. Summary of Load Allocation to Batterson Park Pond.

Non-point Source	Total Nitrogen (kg/yr)	Total Phosphorus (kg/yr)
Surface water base flow	2212	1
Internal Sediment Loading	223	24
Waterfowl	356	75
Other (groundwater, precipitation)	267	28
Total Load Allocation	3058	128

Waste Load Allocation

There are no known continuous point source discharges of nutrients in the Batterson Park Pond watershed at this time. Most residences and commercial or industrial properties in the watershed are tied into the municipal sanitary sewer system. The Publicly Owned Treatment Facility where wastewater from the watershed is treated is discharged into the Farmington River in Farmington. Stormwater discharges potentially regulated as point source discharges were separated from the overall non-point source load (Table 5). The wasteload allocation to regulated stormwater represents an approximate 46-52% reduction from current loads. No additional wasteload allocations have been made to accommodate future growth in this TMDL. Any discharge permits that may be granted in the future (such as stormwater permits) will require BMPs as necessary to insure that the combined regulated and non-regulated stormwater loading of nutrients to Batterson Park Pond established in this TMDL is not exceeded.

Table 5. Summary of Waste Load Allocation to Batterson Park Pond.

Point Source	Total Nitrogen (kg/y)	Total Phosphorus (kg/y)
Regulated Stormwater	1885	94
Other Point Source / Future growth	0	0
Total Waste Load Allocation	1885	94

MARGIN OF SAFETY

Federal regulations require that all TMDL analyses include a margin of safety (MOS) to account for uncertainties regarding the relationship between load and wasteload allocations, and water quality. The MOS may be either explicit or implicit in the analysis, or both

The margin of safety applied in this TMDL is implicit in the analysis. The entire loading analysis employed in developing this TMDL is based on total nitrogen and total phosphorus loads, while the impact of those loads will be a function of nutrient availability. Ortho-phosphorus levels from the 20 water samples collected in 1991-1992 averaged 81% of the total

phosphorus level and dissolved nitrogen concentrations averaged 40% of total nitrogen concentrations. Although some portion of the particulate fraction of TN and TP is likely to become available within a short time, much of the particulate fraction will be incorporated into the lake sediment and any later release is already accounted for as internal load. This suggests an implicit MOS of up to 60% for nitrogen and 19% for phosphorus.

Most guidance for developing TMDLs discourages the use of arbitrary MOS values in favor of an MOS implicit in the TMDL by virtue of calculation method or an explicit MOS derived from statistical analysis of uncertainty (USEPA ⁽¹⁹⁾, Walker ⁽²⁰⁾). Uncertainty in stormwater dominated systems is very high, as temporal variability in loading is large. Even with substantial sampling, characterization of this uncertainty is difficult and likely to lead to a MOS of more than 25%, perhaps even 50%. As the proposed loading targets are to be achieved mainly by addressing stormwater inputs (the primary source of the variability) and internal inputs, which can also be difficult to measure and highly variable depending on oxygen concentrations, there is little benefit to be gained by incorporating a large margin of safety.

Finally, the target loads contain enough uncertainty that the TMDL should be viewed as setting the direction and magnitude of needed change, not an absolute number that can be counted upon to be the endpoint of all management. Based on temporal loading variation, conditions could be much worse or much better at any instant in time than predicted by models into which average loads are inserted. Setting and achieving a TMDL for a system such as Batterson Park Pond should be an iterative process, with realistic goals over a reasonable timeframe and adjustment as warranted by ongoing monitoring. The selected targets represent reductions that will require substantial time and effort to be attained. Adding an explicit MOS at this time has little meaning within the greater context of meeting use attainment goals at Batterson Park Pond.

TMDL SUMMARY

TMDLs for total nitrogen and total phosphorus were established as the annual loads predicted to remain after the appropriate reductions are achieved. The target loads represent what can be achieved through aggressive watershed and in-lake management. Any future land use change that potentially increases loading will be expected to incorporate BMPs that limit loads appropriately. If the entire load allocation for the watershed is already used up (as it is today), multiple areas will have to be managed to achieve no net increase in loading. This is the approach currently applied in Maine with regard to watershed development, and while starting conditions may be closer to the natural trophic category in many Maine lakes, the process of “load re-allocation” to maintain a stable load has merit here. Post-BMP Implementation loads, expressed as annual values constituting the TMDL are summarized in Table 6.

Table 6. Summary of Estimated Current Nitrogen and Phosphorus Loading, and Total Maximum Daily Load Analysis for Batterson Park Pond.

	Current Total Nitrogen (kg/yr)	Target* Total Nitrogen (kg/yr)	Current Total Phosphorus (kg/yr)	Target* Total Phosphorus (kg/yr)
LOAD ALLOCATION				
Surface Water Base Flow	3344	2212	1	1
Non-regulated Stormwater Runoff	0	0	0	0
Internal Sediment Loading	223	223	49	24
Waterfowl	713	356	150	75
Atmospheric Deposition	267	267	28	28
TOTAL LOAD ALLOCATION	4547	3058	228	128
WASTELOAD ALLOCATION				
Regulated Stormwater	3926	1885	174	94
Other Point Sources / Future Growth	0	0	0	0
TOTAL WASTELOAD ALLOCATION	3926	1885	174	94
MARGIN OF SAFETY		Implicit		Implicit
TOTAL MAXIMUM DAILY LOAD	8473	4943	402	222

* Please see page 17 for information regarding variation in the TMDLs.

Once the TMDLs are achieved, the resultant trophic category for Batterson Park Pond according to the system adopted by the State of Connecticut will be mesotrophic, the natural trophic category for Batterson Park Pond. Post-TMDL implementation in-lake conditions derived from the average of the results of several empirical models using the target nitrogen and phosphorus loading are summarized in Table 7. It is estimated that in-lake concentrations of nitrogen and phosphorus will be 498 and 22 ug/L, respectively. Predicted mean chlorophyll *a* and Secchi disk transparency (SDT) values under those conditions are 8.4 ug/L and 2.2 m, typical mesotrophic values. Predicted maximum chlorophyll *a* is 28.5 ug/L, while predicted maximum SDT is 4.1 m. Extreme values may fall outside the mesotrophic category range for a brief period, but this is not expected to happen on a regular or sustained basis.

Based on this analysis, there is a high probability that the lake will be restored to a mesotrophic condition and recreational uses associated with mesotrophic lakes in Connecticut will be fully supported.

Table 7. Predicted Post-TMDL Implementation Conditions in Batterson Park Pond.

	Post-TMDL Conditions	Mesotrophic Category Conditions
Average In-Lake Total Phosphorus	22 ug/l	10-30 ug/l spring and summer
Average In-lake Total Nitrogen	498 ug/l	200-600 ug/l spring and summer
Average In-lake Chlorophyll <i>a</i>	8.4 ug/l	2-15 ug/l mid-summer
Average In-lake Secchi Disk Transparency	2.2 meters	2-6 meters mid-summer

The TMDLs are not far above predicted background (undeveloped) levels (N=446ug/L, P=24ug/L), and are consistent with expectations based on documented BMP performance (Schueler⁽²¹⁾). Compliance with current narrative water quality standards and criteria for use attainment appears achievable with nitrogen and phosphorus total annual loads of 4,943 and 222 kg/yr, respectively.

SEASONAL VARIATION

The TMDL, expressed as an annual target load, should be protective for all seasons since inputs are driven mainly by precipitation, which is distributed roughly evenly over the year on a long-term basis (USDOC⁽²³⁾). However, the precipitation pattern in any given year can vary dramatically from the long-term trend on a weekly to seasonal basis. Also, runoff is the actual vehicle for most nutrient transport, and runoff generation depends on factors additional to precipitation. Spring inputs may be more influential than other seasonal loads as they coincide with the start of the growing season in Connecticut.

Batterson Park Pond flushes approximately twice per year but as with precipitation patterns, variability can be substantial. The most critical time appears to be late spring and early summer, as loads just prior to this time period may be larger than average and flushing rate tends to decline during this period. In addition to the spring load from the watershed, the onset of summer stratification and accelerated decomposition processes signal the initiation of higher internal loading of phosphorus via sediment release. Intense summer storms followed by extended periods of dryness may also represent critical sequences, as nutrients may enter the lake in large quantity in a short burst without sufficient water to flush the system.

Ideally, the loads associated with key units of time would be as follows:

- Seasonally: No more than 1/4 of the annual load should occur in each of the spring and summer seasons (TP ≤ 55 kg/season, TN ≤ 1,236 kg/season). Larger loads in spring or summer could cause a failure to meet use attainment goals, even if the annual target is not exceeded. High loading during spring or summer can not be offset by lower fall or winter

loading, given the timing of the growing season and the flushing characteristics of Batterson Park Pond.

- Monthly: No more than 1/3 of the seasonal load should occur in any given spring or summer month ($TP \leq 18$ kg/month, $TN \leq 412$ kg/month). Larger loads in any one month may be offset by lower loads in a subsequent month, but as changes in loading generally equate with changes in flushing in the Batterson Park Pond system, the impact of elevated loads over a late spring or summer month may be disproportionately large. That is, if storm-induced loads of nutrient-rich runoff flush cleaner water out of the lake in late spring or summer and then remain without further significant dilution for an extended period, use attainment may be compromised.
- Weekly or Daily: Loading over periods shorter than monthly is not especially meaningful in this system. The nature of mixing and flushing in lake systems like Batterson Park Pond is such that the impact of inputs is expressed over a period of time roughly equal to at least three flushings (1.6 years).

MONITORING PLAN

The monitoring plan described below incorporates the assessment of BMP effectiveness and applicability of target loads generated in this TMDL.

It is recommended that paired dry weather – wet weather samples be collected three times each summer, between May 15 and October 1, at the three main tributaries (sampling locations BPP 1 – BPP 3 from the DWQS) and at any stormwater discharge pipe directly entering the lake that is targeted for management. Parameters should include total phosphorus, dissolved phosphorus, TKN, ammonium and nitrate nitrogen, and suspended solids or turbidity.

In-lake conditions should be assessed through monthly measures of total phosphorus, dissolved phosphorus, TKN, ammonium and nitrate nitrogen, temperature, dissolved oxygen, and water clarity from June through September at the top and bottom of the water column. If funds allow, phytoplankton samples should be analyzed on a monthly basis as well, to ascertain what types of algae are present and at what densities. Zooplankton analysis would also be useful, with one sample in the late spring and one in late summer, as zooplankton community features reflect both grazing pressure and food for smaller fish. On a one-time basis, three surficial sediment samples should be collected within the anoxic zone of the lake. Sediments should be analyzed for total and available phosphorus (including a new extraction process that indicates recycling potential). This information will be important in the calculation of inactivator dose for internal phosphorus load inactivation.

Waterfowl counts should be made concurrent with in-lake water quality surveys. Pre- and post-treatment surveys should be conducted in association with any deterrent systems that are implemented. Likewise, the rooted plant assemblage should be mapped about every three years using standardized transects and methods. If in-lake techniques are used to control aquatic plants, these areas should be subjected to pre- and post-treatment surveys annually.

IMPLEMENTATION PLAN

It is recommended that a Batterson Park Pond Water Quality Committee be formed between the City of Hartford and the Towns of Farmington and New Britain. The committee should refer to the Water Quality Improvement Project - Design Study Report (WQIMP) prepared by Fuss & O'Neill, Inc. in 2001⁽²⁴⁾ to initiate an evaluation of appropriate Best Management Practices to limit nutrient loading to Batterson Park Pond. Techniques to reduce nitrogen, phosphorus, and sediment loading in this system should be focused on stormwater management, waterfowl control, and internal phosphorus loading from the pond sediments. Controlling sedimentation related to erosion in the watershed goes hand and hand with controlling nutrients. An aggressive nutrient program will control sediment loading as well. Stormwater sediment control guidance can be found in the 2004 Connecticut Stormwater Manual located on the DEP's website at www.dep.state.ct.us/wtr/wtr/stormwater/strmwtrman.htm. Some general lake management techniques listed in Table 8 and Table 9 provide a possible action schedule. More specific information regarding each technique listed in Table 8 can be found in "Managing Lakes and Reservoirs", a manual prepared by the North American Lake Management Society and the Terrene Institute in cooperation with the USEPA (Holdren, et. al.⁽²²⁾).

Enhancing environmental quality of Batterson Park Pond will involve reducing the loading of phosphorus, nitrogen, fecal bacteria, sediment and other pollutants in stormwater discharged to the lake or its tributaries. In-lake management should include reduced internal recycling of phosphorus, increased oxygen concentrations in deep water, enhanced grazing of zooplankton on algae, and control of rooted plant species. Waterfowl deterrents should be implemented to reduce direct loading of nitrogen and phosphorus, which eventually becomes incorporated into the internal load.

Watershed management options included source reduction techniques and pollutant transport mitigation methods, while in-lake management options included mainly methods for reducing algae, rooted plant, and waterfowl abundance and for increasing deep water dissolved oxygen concentrations. The resultant plan includes multiple techniques with some overlap and flexibility of application. The plan is intended to evolve as it is implemented, with decisions based on both funding opportunities and the success of program implementation.

Stormwater management involves source controls through education, pre-treatment with street sweeping, catch basin cleaning, and oil/grit chambers, and renovation with buffer strips or detention and/or infiltration of stormwater. A concurrent effort to minimize future impacts from development of the watershed includes land use planning and exercise of current environmental regulations to minimize stormwater pollution. The cost of major structural improvements in watershed stormwater management is on the order of \$3,000,000 to \$5,000,000 over an implementation period of about a decade. Additional reductions in pollutant loading are expected from non-structural methods such as education and planning at a cost on the order of \$100,000 over a decade. Enforcement of existing regulations at no itemized additional cost to present programs would further aid water quality improvement. Benefits to habitat and human use for both recreation and water supply are expected to be consistent with perceived goals for the Batterson Park Pond system.

Improvement of the quality of stormwater runoff entering Batterson Park Pond will not be a rapid or inexpensive process, but is achievable with persistent effort and adequate funding. Sustained adequate funding will be the primary determinant of success in meeting this TMDL through stormwater management. Based on the WQIMP, the priority order for installation of stormwater management devices (e.g., detention or infiltration systems) should be selected in order to maximize efficiency in achieving the TMDL. Engineered designs and permits will have to be prepared following selection of stormwater devices. Implementation is expected to require about a decade of effort.

While watershed management is generally and justifiably viewed as the most desirable approach to water resource protection and enhancement, control of waterfowl and internal recycling are also critical components of the program in this case. Many waterfowl, particularly Canada geese, prefer open waterbodies adjacent to large open areas of lawn or field. Batterson Park Pond provides an ideal habitat in this regard. Large numbers of these birds can alter nutrient recycling in waterbodies, decrease water quality (including elevating bacteria counts), and become a nuisance to lake users. While a diverse waterfowl community may be enjoyed by many, the overpopulation of the lake with non-migratory Canada geese is a problem.

Reducing waterfowl numbers does not come without controversy. Many methods have been used for mitigation, some of which are lethal. Some area residents and lake users may object to any mitigation, even non-invasive deterrents. Ongoing communication with the public is a large component in any waterfowl control program. If Batterson Park Pond is to meet the target nutrient loading, waterfowl control is necessary.

Assuming public endorsement, the waterfowl control program could include:

- Landscape Alteration – It has been shown that vegetation over 12 inches in length deters geese. Canada geese prefer environments where they can walk onto shore and graze. Select planting of vegetation (dense growths) would create a natural barrier between open park areas and the lake, resulting in a less hospitable habitat for geese.
- Fencing – Installing a low fence or other physical barrier functions in the same manner as landscape alteration but incorporates a non-natural barrier between the shore and park areas. This barrier is usually less attractive, but can be removed to allow human access, as at the actual beach area.
- Hazing – Noise making or the use of dogs works well in many cases, but creative implementation is necessary. Successful harassment requires the stimulus at the point of landing on the lake and removal of the harassment once the birds are in flight (a punishment/reward system). Automated noise makers need to be moved periodically, as birds will acclimate to the noise. Trained dogs are effective if they maintain herding behavior.
- Repellants – Methyl anthranilate, a natural sweet flavored compound distasteful to geese, has been found to reduce the congregation of Canada geese when sprayed on their feeding grounds. More than one application a season appears necessary to repel geese from lawn or park areas, and it may not be completely effective by itself.
- Visual Deterrents – Visual deterrents such as balloons, scare tape and scarecrows vary in deterrent efficacy. Visual deterrents have been more effective when combined with other waterfowl mitigative measures. Geese can become acclimated to the structures, so moving the structures occasionally will be necessary.
- No-feeding Ordinance – The municipality can prohibit feeding of waterfowl; “No Feeding” signs should be placed in the park. In addition to the no-feeding ordinance, geese can be discouraged from taking food from humans by feeding the geese bread tainted with dimethyl anthranilate or other non-harming distasteful products.
- Public Outreach and Education – Public education on waterfowl controls will be necessary to obtain public compliance. Low cost signs and brochures advising people of problems with geese and how feeding them increases these problems should be provided. A display in the park detailing problems with feeding and attracting too many geese and what the public can do to minimize their effect would be appropriate. A short video public service announcement could also be aired on the local television stations.

Lethal techniques are assumed to be not practical in this case, given the location of the park in a residential area. Egg addling might be effective in reducing the resident Canada geese population. Development and implementation of an aggressive waterfowl management plan over 1 year is expected to cost approximately \$70,000 but could be as high as \$200,000 depending on volunteer involvement and the degree of landscape modification. Involving the public and civic organizations in the creation of posters/pamphlets/videos decreases overall costs

and increases the probability of successful execution and compliance with the waterfowl management plan.

Reducing the in-lake recycling of phosphorus can be accomplished by inactivation of the surficial phosphorus reserves with a compound such as alum and/or destratification by aeration that would prevent anoxia and associated increases in sediment phosphorus release. Additionally, while not strictly a recycling prevention technique, enhanced grazing by zooplankton can minimize the accumulation of algal biomass, increase water clarity, and generate a food resource for a healthy fishery.

The use of alum to inactivate sediment phosphorus has been very successful in many cases, but will not prevent new accumulation and recycling where watershed inputs are not controlled. Benefits tend to last for about three times the detention period of the lake, so a proper treatment should provide improved conditions for more than a year. This could be a valid interim strategy for achieving desired conditions while the complete program is being implemented, but would be an expensive long-term strategy by itself. Each alum treatment, at a dose sufficient to inactivate phosphorus reserves in the upper 4 cm of sediment, would cost about \$100,000.

Mixing of this fairly shallow lake could increase oxygen levels near the bottom and limit phosphorus release. Termed “destratification” or “artificial circulation”, this approach most often involves installation of diffusers that supply enough air to keep the lake in a state of constant mixing. The system would be run only during late spring and summer, when internal recycling is greatest. Capital cost for an appropriate system for Batterson Park Pond would be between \$100,000 and \$200,000, with an annual operational cost of up to \$10,000. While the oxygen benefits favor use of this approach in water supplies or major fisheries, inactivation with aluminum is preferred for most recreational lakes for cost reasons. However, a mixing/aeration system with the capability to deliver a phosphorus inactivator as well can provide the benefits of both approaches and might be considered if desired conditions are to be achieved and maintained during an extended watershed management implementation period.

Rooted plant control can best be accomplished through a combination of treatment with a herbicide containing fluridone as the active ingredient on a periodic basis, with supplementation of control in localized areas such as beaches and boat ramps through the application of benthic barriers. Total cost of the suggested plant control program over a 10-year period is \$250,000. While this element is not necessary to achieve the nutrient-based TMDL, it is an important component of overall lake management, given the current problems and desired uses of Batterson Park Pond.

Table 8. Management Options

Watershed Management

- Source Reduction
 - Behavioral Modifications
 - Zoning and Land Use Planning
 - Bank and Slope Stabilization
- Transport Mitigation
 - Street Sweeping
 - Catch Basin Cleaning
 - Catch Basins with Sumps and Hoods
 - Oil/Grit Chambers
 - Infiltration Systems
 - Detention Systems
 - Buffer Strips

In-Lake Management – Algal Control and Dissolved Oxygen Enhancement

- Phosphorus Inactivation
- Destratification
- Enhanced Grazing

In-Lake Management – Rooted Aquatic Plant Control

- Benthic Barriers
- Fluridone Treatment

In-Lake/Shore Line Management – Waterfowl Control

- Landscape Alteration (mainly plantings)
- Fencing
- Hazing
- Repellants
- Visual Deterrents
- No-feeding Ordinance
- Public Outreach and Education

Monitoring

- In-lake and watershed monitoring as described in previous section.

Table 9. Proposed Schedule for Completion

	YR 1	YR2	YR3	YR4	YR5	YR6	YR7	YR8	YR9	YR10
Watershed Management										
Source Reduction										
Behavioral Modifications	X	X	X	X	X	X	X	X	X	X
Zoning and Land Use Planning			X			X			X	
Bank and Slope Stabilization	X	X	X	X	X	X	X	X	X	X
Transport Mitigation										
Street Sweeping/Catch Basin Cleaning	X	X	X	X	X	X	X	X	X	X
Catch Basins with Sumps and Hoods			Require for all new construction; retrofit as opportunities arise							
Oil/Grit Chambers			X	X	X	X	X			
Infiltration Systems			X	X	X	X	X			
Detention Systems			X	X	X	X	X			
Buffer Strips	X	X	X	X	X	X	X	X	X	X
In-Lake Management – Algal Control and Dissolved Oxygen Enhancement										
Phosphorus Inactivation		X	Alternative to destratification. Follow up treatments as necessary							
Destratification		X	X	X	X	X	X	X	X	X
Enhanced Grazing (stocking/fishing reg.)			X	X	X	X	X	X	X	X
In-Lake Management – Rooted Aquatic Plant Control										
Benthic Barriers (beach area)		X	X	X	X	X	X	X	X	X
Fluridone Treatment (whole lake)		X			X			X		
In-Lake Management – Waterfowl Control										
Habitat Alteration (plantings, fencing)	X	X	X	X	X	X	X	X	X	X
Hazing/Repellants/Visual Deterrents	X	X	X	X	X	X	X	X	X	X
No-feeding Ordinance	X									
Public Outreach and Education	X	X	X	X	X	X	X	X	X	X
Monitoring	X	X	X	X	X	X	X	X	X	X

REASONABLE ASSURANCES

Although not required for TMDL approval where only non-point sources are involved, reasonable assurance that the TMDL will be implemented is certainly desirable. As mentioned earlier, Batterson Park Pond is owned by the City of Hartford but located within the towns of Farmington and New Britain. The City of Hartford started the process of improvement in 1993 with the DWQS and in 2001 with the WQIMP, but major progress towards improved lake conditions has been hampered by funding and the challenges of managing a watershed outside the political jurisdiction of the City. A cooperative and comprehensive program has yet to be developed. It is expected that the City of Hartford will continue to take steps toward improving Batterson Park Pond using the DWQS and WQIMP as the framework for implementation of a management program. The current primary impediment to successful achievement of the TMDL for nutrient loading is funding. It may not be reasonable to assume that funding will be sustained at necessary levels without assistance at the State and Federal level. This may slow progress in what is already perceived as a ten-year program.

PUBLIC PARTICIPATION

The City of Hartford has held public meetings concerning the assessment and improvement of water quality in Batterson Park Pond, mostly in association with the DWQS. The Batterson Park Pond TMDL document was noticed for public comment in the Hartford Courant on October 8, 2004. In addition, the City of Hartford and Towns of Farmington and New Britain, as well as several interested parties were notified by mail of the comment period. As of the end of the public review period (November 12, 2004), one comment letter regarding the TMDL document was received by the DEP. The DEP reviewed the comment letter and made revisions to the document where appropriate. A response to the comment letter was also prepared by the DEP. It is expected that open forums will continue as implementation of the management plan continues.

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Appendix A

Impact of Post-BMP Implementation Nutrient Loadings on Designated Uses

A series of models were used to evaluate anticipated in-lake conditions following implementation of BMPs to achieve the necessary reductions discussed above. This section provides an evaluation of the model with regard to the WQS for mesotrophic conditions. As explained in the "Applicable Water Quality Standards" section, the natural trophic state for Batterson Park Pond is expected to be mesotrophic to late mesotrophic. It can be assumed that if water quality in Batterson Park Pond falls within the ranges of nutrients, chlorophyll *a*, and transparency specified for its natural trophic category in Connecticut WQS, all designated uses will be supported since support of designated uses is dependent on maintaining the lake in its natural trophic category. Table A-1 provides the required annual loading in order to bring Batterson Park Pond into the range of trophic classification values for mesotrophic systems.

Table A-1. State of Connecticut Trophic Classification Range for Mesotrophic Waterbodies and Corresponding Annual Load to Batterson Park Pond.

Parameter	Water Quality Criteria Ranges	Annual Load (kg/yr)
Total Nitrogen	200 – 600 ug/L	1282 – 3847
Total Phosphorus	10 – 30 ug/L	111 – 351
Chlorophyll <i>a</i>	2 – 15 ug/L	TP Load = 83 – 409
SDT*	2 – 6 meters	TP Load = 60 – 289

* SDT = Secchi Disk Transparency

Empirical Equations

Mean and maximum chlorophyll *a* and SDT levels were predicted using empirical equations derived for northern temperate lakes from substantial databases^(10, 25, 26, 27, 28). Relationships observed for groups of lakes are not precisely applicable to any one lake in the data set or to any other lake from the region. However, they do provide a conceptual basis for predicting the direction and magnitude of change expected in targeted lake features when nutrient loads are altered. Table A-2 lists the predicted chlorophyll *a* and SDT values using the additional literature relationships. The predicted in-lake values match well with the Connecticut trophic classification range for mesotrophic waterbodies. In addition, the mesotrophic range matches well with predicted natural values (absence of human influence and/or practical reduction in anthropogenic loading achievable through BMPs).

Table A-2. Predicted Mean and Maximum Chlorophyll *a* and SDT Values with a 60% Nitrogen and Phosphorus Reduction of Watershed Load, 50% Nitrogen Reduction in Waterfowl Loading, and 50% Phosphorus Reduction of Waterfowl and Internal TP Load.

Source	Predicted In-Lake TP (ug/L)	Predicted Mean Chl (ug/L) ¹	Predicted Max Chl (ug/L) ²	Predicted Mean SDT (m) ³	Predicted Max SDT (m) ³
Existing DWQS	41	18.7	61.6	1.3	3.5
Existing Raw Data	26	10.6	35.8	1.9	3.9
Empirical Model Average ⁴	26	10.6	35.8	1.9	3.9
Land Use Export	22	8.4	28.5	2.2	4.1

¹ From average of Dillon and Rigler⁽²⁵⁾, Jones and Bachmann⁽¹⁰⁾, Oglesby and Schaffner⁽²⁶⁾, and Modified Vollenweider⁽²⁷⁾.

² From average of Modified Vollenweider⁽²⁷⁾, and Modified Jones, Rast and Lee⁽²⁸⁾.

³ From Oglesby and Schaffner⁽²⁶⁾ (Avg) and Modified Vollenweider⁽²⁷⁾ (Max).

⁴ Assumed 30% of the total phosphorus load came from waterfowl, 23% from internal loading and 34% came from surface water. These percentages are the average percent contribution from DWQS, Raw Data and Land Use budgets. It should be noted that the 60% reductions within the export coefficient model were taken only in urban land use areas. The other three budgets do not separate out land uses; therefore 60% reduction was applied to all surface water loads, providing an overestimate of reduction.

Trophic State Index

Lake use impairment was correlated to the Trophic State Index (TSI) developed by Carlson⁽¹⁴⁾ and presented in the National Nutrient Guidance Manual for Lakes and Reservoirs⁽²⁹⁾. When developed by Carlson, the TSI was used to simplify water quality assessment of lakes. It is currently used by many states for trophic classification. The National Nutrient Guidance Manual for Lakes and Reservoirs describes changes in trophic states of lakes with use-related problems. TSI values for use criteria are presented in Table A-3. As such, if these values are attained, then designated uses can be considered supported. It is important to note that industrial and agricultural supplies were not addressed in the National Nutrient Guidance Manual, and complications introduced by macrophyte problems were not covered by Carlson's TSI. In addition, when applying this approach, it is important to remember that this TMDL has been prepared to guide management for recreational uses, not water supply management.

Table A-3. Designated Use and Associated TSI* (Adapted from EPA 2000).

Lake Use	TSI
Potable Water	≤ 40
Recreation	
Swimming/Primary contact recreation	≤ 60
Boating and Secondary contact recreation	≤ 70
Fish	
Salmonid fishery	<40-50
Percid fishery	50-60
Centrarchid fishery	60-80
Cyprinid fishery	>70-80
Wildlife (Aquatic Life)	No TSI Criteria.

* = TSI values based on calculations using the average summer values of Secchi Disk Transparency (SDT), chlorophyll *a*, phosphorus, and nitrogen.

Carlson⁽¹⁴⁾ and Frink and Norvell⁽¹³⁾ established mathematical relationships between in-lake phosphorus concentrations and SDT and chlorophyll *a* concentrations. Carlson's relationships were based on lakes throughout North America, whereas Frink and Norvell's relationships were based on lakes in the State of Connecticut.

Equations used by Carlson and Frink and Norvell are:

Carlson

$$\text{SDT} = 48/\text{TP} \qquad \text{Chl } a = 1.449 \cdot \ln \text{TP} - 2.442 \qquad \text{SDT} = 2.04 - 0.68 \cdot \ln \text{Chl } a$$

Frink and Norvell

$$\text{No equation} \qquad \text{Chl } a = 0.374 + 0.431 \cdot \text{TP} \qquad \text{SDT} = 1 / (0.0277 \cdot \text{Chl } a + 0.1235)$$

Applying these equations to the predicted total phosphorus in-lake concentration after a 60% reduction in watershed total phosphorus load, 50% reduction in waterfowl loading and a 50% reduction in internal load yields a range of SDT values of 0.4 to 2.9 meters (Table A-4), provided water transparency is linked to total phosphorus. Non-algal turbidity will weaken the strength of this relationship, and is an issue at times in Batterson Park Pond. Chlorophyll *a* concentrations are predicted to range from 6.4 to 18.0 ug/L using both Chl *a* equations above. Mean and maximum chlorophyll *a* and SDT values using empirical models were presented in Table A-4.

Table A-4. Predicted Chlorophyll and SDT with 60% Nitrogen and Phosphorus Reduction of Watershed Load, 50% Nitrogen and Phosphorus Reduction in Waterfowl and 50% Phosphorus Reduction of Internal TP Load.

Source	Method	TP Load Post Reduction (kg/yr)	Predicted In-Lake TP (ug/L)	Predicted Mean Chl (ug/L) ^A	Predicted Mean SDT (m) ^A
Existing DWQS	1	427	41	15.9 – 18.0	0.4 – 1.8
Existing Raw Data	2	257	26	8.2 – 11.6	0.8 – 2.9
Empirical Model Average	3	259	26	8.2 – 11.6	0.8 – 2.9
Land Use Export	4	221	22	6.4 – 9.9	1.1 – 3.3

^A = Range from Carlson⁽¹⁴⁾ and Frink and Norvell⁽¹³⁾

It should be noted that the 60% reductions within the export coefficient model were taken only in urban land use areas. The other three budgets do not separate out land uses; therefore 60% reduction was applied to all surface water loads, providing an overestimate of reduction.

Using the predicted SDT, chlorophyll, and TP derived from the empirical models assuming a 50% internal, 50% waterfowl, and a 60% watershed load reduction, Batterson Park Pond would have estimated TSI values as follows:

TSI of transparency = 43 – 59

TSI of chlorophyll = 49 – 53

TSI of phosphorus = 49

A 50% internal, 50% waterfowl, and a 60% watershed load reduction in total phosphorus loading would result in achieving consistency with use-based (TSI-scored) criteria for recreation (Table A-3).

Applying an approach developed by Vollenweider⁽³⁰⁾, it is estimated that a total annual phosphorus load of 207 kg/yr would be required to reach the “Permissible Limit”, the maximum load a system can handle without periodic or seasonal detrimental effects. This equates to a TP concentration of about 20 ug/L. A maximum annual phosphorus load of 414 kg/yr would be required to reach the “Critical Limit”, the maximum load a system can handle without substantial productivity problems (severe and frequent algal blooms). This corresponds to a TP concentration of about 40 ug/L. Batterson Park Pond would fall between the Permissible and Critical Limits under project post-BMP conditions using the land use export coefficient model.

The implementation of BMPs in the watershed (TMDL based on best practical reduction) will put Batterson Park Pond in the mesotrophic range based on the Connecticut trophic classification system. It should be noted, however, that attainment of the target nutrient loads does not guarantee immediate full support for all uses designated for Batterson Park Pond. For example, additional in-lake techniques for control of rooted aquatic vegetation may be required to enhance recreational opportunities in the near term.